Sand Ripple Dynamics on the Inner Shelf

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LONG-TERM GOALS

The prediction of bedforms in coastal regions.

OBJECTIVES

To comprehensively investigate the genesis, dynamics, morphology, and evolution of bedforms found in sandy inner-shelf environments, with emphasis on those bedforms that affect the penetration of sound into the seabed.

APPROACH

We will utilize a combination of field observations, laboratory experiments, and numerical modeling to determine the relationships between ripple morphology, wave and current conditions, and sediment characteristics.

WORK COMPLETED

A suite of instrumentation and laboratory apparatus has been designed and assembled for field and laboratory observations of bedforms.

Field observations were obtained near Fort Walton Beach, FL, during the period of Sept 25-28, 2004. We obtained measurements of ripples and sediment size using optical and acoustical methods at approximately 50 locations. Five grab samples were also obtained. The main transects were cross-

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shore from 5 to 40 meters depth (approximately at 86 38' W from 30 23.6' to 30 6.4' N), and longshore (approximately 30 22.8' N from 86 38.1' to 86 39.4' W) in 18 to 20 meters depth.

Numerical model development has been initiated. Two approaches are being pursued simultaneously. In the first approach, the hydrodynamics are modeled using Large Eddy Simulations and the seabed interface is evolved by calculating the local time dependent scour and accretion over each portion of the sand ripple. Sediment fluxes to and from the bed are determined by relationships between the near-boundary fluid velocities and empirical formulations for bed-load and suspended sediment load. In the second approach, the sea-bed is modeled as a porous layer of sand-water mixture using a continuum approximation. Here the mixture has bulk properties (density, viscosity, and particle pressures) depending on the local concentration of the sediment. In this approach sand ripples naturally evolve over wave cycles in response to scouring and deposition and pressure anomalies on the surface of the ripples.

RESULTS

Fine sediment and other material were generally found in the water column and also on the seabed. The amount of fine material on the seabed was highly variable, at some locations consisting of a layer less than 1 mm, and other locations several cm. Patches with thick mud deposits were generally flat, but regions with sand-shell and thin mud deposits were generally rippled, including the deepest sites measured. An example from the recently competed field observations is shown below. These measurements were made in 23 meters depth approximately south of the SAX04 field site soon after the passage of hurricane Ivan. These observations, along with others, suggest that hurricane generated waves formed ripples across the inner shelf.
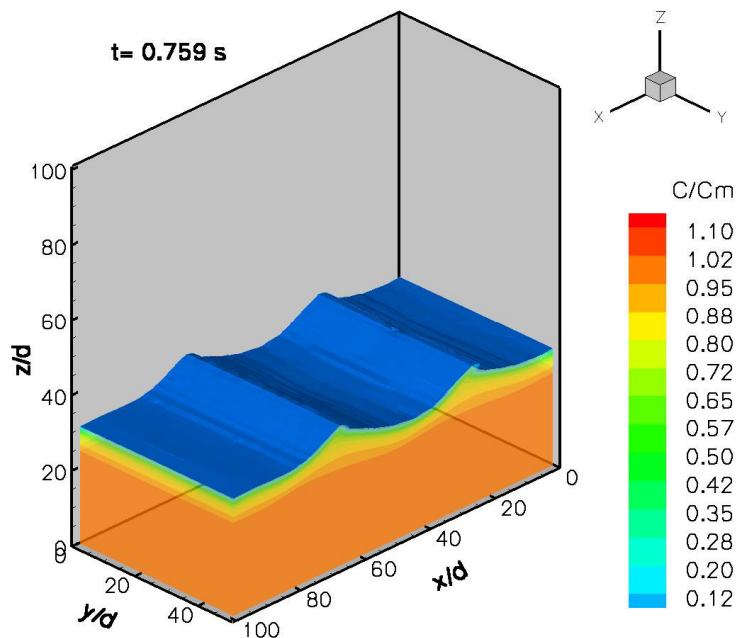

Figure 1. Transient sand ripples that evolved during model experiments using the continuum approach for a live bed from preliminary numerical experiments.

Model experiments are at a preliminary stage. Under strong wave forcing conditions ripple-like features develop in the sea-bed during transition from weak to strong flow conditions. At this stage we are adding additional rigidity to the sea-bed by including particle-particle pressure forces to attempt to stabilize the ripple formations for longer periods of time as observed in nature.
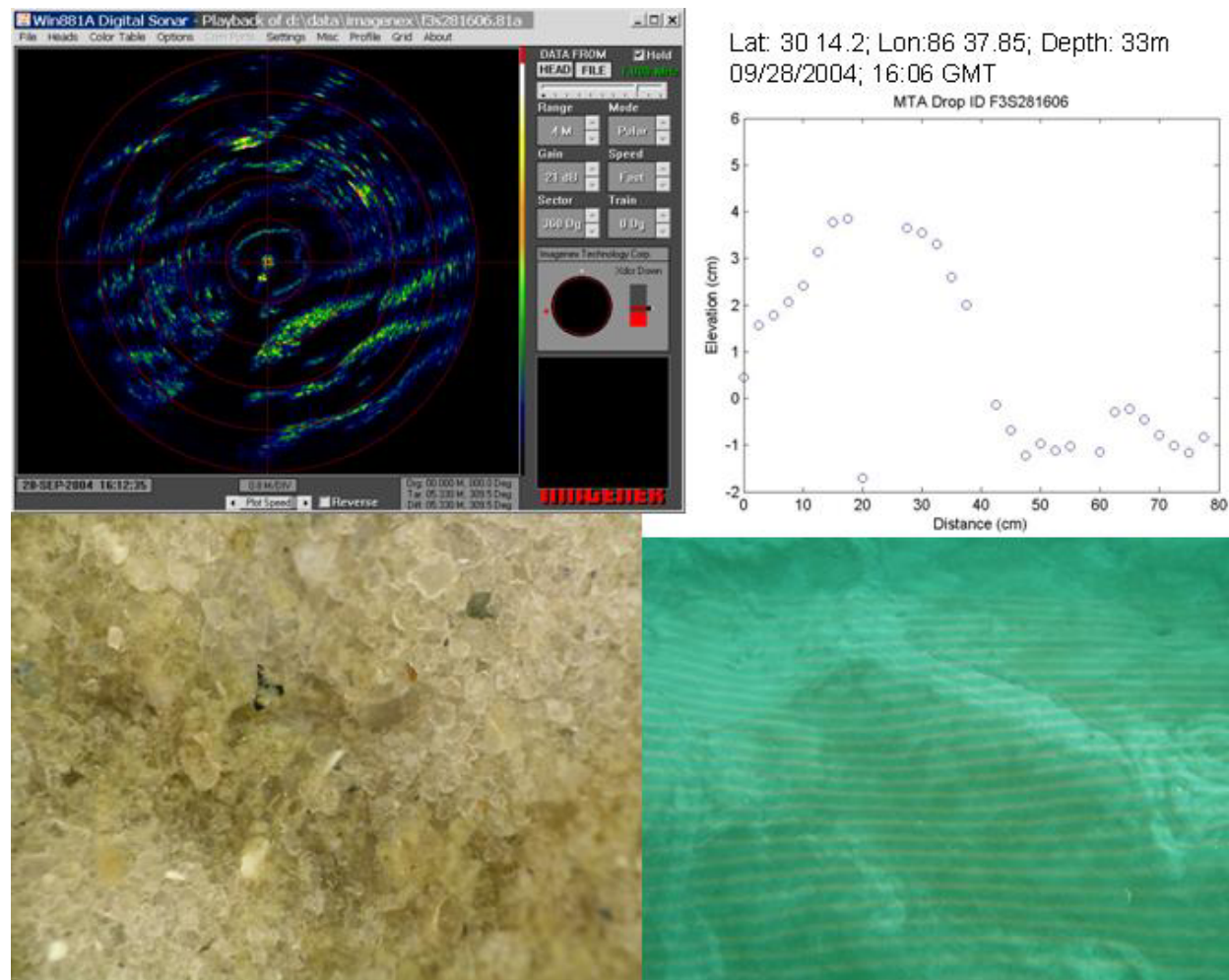

Figure 2. Bedforms observed during the Sand Ripple experiment in Ft. Walton beach Florida, from Acoustic images (upper left panel), ripple amplitude and wavelength (upper right panel), observations of grain size from optical images of the seabed (lower left panel) and larger scale images of sand ripples on the sea-floor.

IMPACT/APPLICATIONS

The accurate prediction of bed-form geometry and orientation will improve buried mine detection techniques.

RELATED PROJECTS

A USGS project, Coastal Evolution: Multi-scale, Process-based Modeling, has a task focused on the wave-boundary layer scale, and has significant synergy with this project.

A related ONR Coastal Geosciences supported project on modeling Sediment Transport in Energetic Wave Bottom Boundary Layers with PI Donald Slinn.

PUBLICATIONS

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